Stability of basalt+anhydrite+calcite at HP-HT: implications for Venus, the Earth and Mars

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"Canali" observed at Venus' surface by Magellan are evidence for very long melt flows, but their composition and origin remain uncertain. The hypothesis of water-rich flow is not reasonable regarding the temperature at Venus' surface. The length of these channels could not be explained by a silicate melt composition but more likely, by a carbonate-sulfate melt which has a much lower viscosity (Kargel et al 1994). One hypothesis is that calcite $CaCO_3$ and anhydrite $CaSO_4$ – which are alteration products of basalts – melted during *meteorite impacts*. A famous example recorded on the Earth (Chicxulub) produced melt and gas rich in carbon and sulfur. Calcite and sulfate evaporites are also present on Mars surface, associated with basalts. An impact on these materials might release C- and S-rich melt or fluid. Another type of planetary phenomenon (affecting only the Earth) might provoke a high pressure destabilization of basalt+anhydrite+calcite. Very high contents of C and S are measured in some Earth's magmas, either dissolved or in the form of crystals (Luhr 2008). As shown by the high H content and high fO_2 of primary igneous anhydrite-bearing lavas, the high S content in their source may be explained by *subduction* of an anhydrite-bearing oceanic crust, either directly (by melting followed by eruption) or indirectly (by release of S-rich melt or fluid that metasomatize the mantle) . Calcite is a major product of oceanic sedimentation and alteration of the crust. Therefore, sulfate- and calcite-rich material may be subducted to high pressures and high temperatures (HP-HT) and release S- and C-rich melts or fluids which could influence the composition of subduction zone lavas or gases.

Both phenomena – *meteorite impact* and *subduction* – imply HP-HT conditions – although the P-T-time paths are different. Some HP experimental/theoretical studies have been performed on basalt/eclogite, calcite and anhydrite separately or on a combination of two. In this study we performed piston-cylinder experiments at 1 GPa between 950 and 1700°C using a mixture of 70wt% tholeiitic basalt + 15wt% anhydrite + 15wt% calcite. Up to ~1440°C, an ultracalcic (CaO>13.5 wt%; CaO/Al_2O_3>1 wt%) picrobasaltic (SiO_2~40-45 wt%; Na_2O+K_2O<2 wt%) melt containing up to 5 wt% SO_3 and up to 5.3 wt% CO_2+H_2O (calculated by difference) is present in equilibrium with clinopyroxene, anhydrite, spinel-chromite, a CAS-phase and a gas composed mainly of CO and an aliphatic thiol $(CH_2)_4SH$. Hydrogen was incorporated either by contact between the starting material and air or by diffusion through the capsule during the experiments. The S content in the gas increases with temperature and run duration, implying that gases with various C/S ratios might be released during an impact or at subduction zones, depending on the P-T-t path and on the H content. Above ~1440°C, a Ca-rich carbonate-sulfate melt forms (in equilibrium with the picrobasaltic melt) which contains a few percents of Na and K. Such melt is not expected to form at Earth's subduction temperatures. If it forms by meteorite impact, it might crystallize too fast to explain long flows like Venus' canali. A different basalt/anhydrite/calcite ratio might, however, decrease its formation temperature.